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ABSTRACT

Health Risk Factors Associated with Acute Respiratory Illness
Among U.S. Army Recruits Attending Basic Combat Training

by

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Uniformed Services University of the Health Sciences

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Background: Little is known regarding the role of smoking history and aerobic fitness in acute respiratory infection (ARI) risk in military trainees.

Objective: Determine smoking history and run group association with ARI during U.S. Army Basic Combat Training (BCT).

Methodology: A de-identified dataset from a nested case-control study (N=2,284) was analyzed for potential risk factors of ARI from surveys administered to diagnosed cases and healthy bunkmate controls. Logistical regression analysis was used to calculate odds ratios and confidence intervals.

Results: The final multivariate logistic regression Total ARI model indicated smoking more than one half pack/day among females (OR=1.46, 0.98-2.16) and males (OR=1.24, 0.97-1.59) was associated with increased ARI. Also, associations tended to be larger among less aerobically fit male and female trainees. Physical stress was also positively associated with ARI while older age for both genders and body mass index for females were protective.

Conclusion: Health promotion strategies to reduce ARI risk may include early smoking cessation and higher initial aerobic fitness prior to BCT among younger aged recruits.

**Health Risk Factors Associated With Acute Respiratory Illness Among
U.S. Army Recruits Attending Basic Combat Training.**

By

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A thesis submitted to the Faculty of the Department of Preventive Medicine and
Biometrics, Uniformed Services University of the Health Sciences in partial fulfillment
of the requirements for the degree
of
Master of Science in Public Health, 2012

DEDICATION

I dedicate this Master of Science in Public Health thesis to the deployed United States Servicemembers who put themselves in harm's way for our freedom and in special memory of LTC David E. Cabrera.

ACKNOWLEDGEMENT

Thank you to my thesis committee for their entrusted mentorship, enduring commitment and steadfast support in pursuit of my MSPH degree and to my wife and children for allowing me this opportunity to pursue this dream.

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INTRODUCTION

Statement of Problem

Acute Respiratory Infections (ARI) are a major cause of illness worldwide.¹ Typically, such viral and bacterial infections are self limiting and not life threatening, but can result in substantial loss of productivity and medical resource expenses. In the U.S. alone 62 million cases of the common cold occur annually resulting in 22 million days of lost work and 20 million days of lost school.² On average, healthy adults can expect to suffer one to three colds per year. In 2010, annual sales of all over-the-counter cough and cold medications in the U.S. was estimated at 4.1 billion dollars.³

In 2010, approximately 85,000 medical encounters for respiratory infections were reported for all Department of Defense recruits attending initial military training.⁴ Lost training hours due to illness can significantly impact a recruits potential to complete BCT and follow-on military occupational specialty training as scheduled. BCT training environments are unique settings that have tended to promote ARI for several reasons. General crowding of communal barracks and increased stress,⁵⁻⁷ along with the assembly of recruits from across the U.S. further heightens the potential for exposure to ARI pathogens for which a recruit may not have immunity. In recent years, ARI among military recruits has been associated with Adenovirus outbreaks.^{5, 7, 8} This was largely due to the loss of the Adenovirus vaccine production. Prior to this production loss Adenovirus vaccine (type 4 and 7) was given to all BCT recruits from 1971-1995.⁵

BCT by design is meant to challenge the trainee to overcome mental and physical stress intended to replicate the rigors of real combat. Several studies have shown an

association between elevated stress and respiratory illness in the general population as well as in a cohort study of U.S. Air Force Academy cadets.¹⁰⁻¹²

Historic epidemiological investigations have associated active smoking with higher risk of ARI during military training.¹³⁻¹⁵ Since tobacco products have been barred from BCT, this study will investigate previous smoking behavior such as the number of cigarettes smoked daily and time since smoking cessation. Afebrile ARI may represent common viral upper respiratory tract infections (URTI) while febrile ARI may comprise more serious lower respiratory tract infections (LRTI) such as pneumonia. Since active smoking has been strongly associated with pneumonia outbreaks,^{16, 17} smoking may also be associated with febrile ARI as a result of increased disease severity.

This study will also highlight the recruit's assigned exercise run group as related to ARI. Regular moderate exercise has many physical and psychological health benefits such as increased energy, stamina, improved mood, weight control, mobility, maintenance of muscle and bone density, as well as improved immune function.¹⁸ Competitive athletes recognize peak performance on the field requires consistent intense practice off the field. Recreational sports enthusiasts to Olympic athletes must therefore carefully balance training intensity, duration, and frequency with risk of injury and acute illness resulting from physical training programs. Exercise work load and risk of URTI has been suggested to share a "J curve" relationship.¹⁹ Suggesting optimal immune function may be achieved with regular moderate exercise workloads as opposed to extremely high or low exercise workloads.

Recruits who enter BCT at a low level of aerobic fitness, as reflected by poor performance on the initial one-mile run test, may experience increased ARI incidence as

a result of over training. Similarly, recruits assigned to faster run groups that exercise at a higher aerobic intensity may experience increased ARI risk from overtraining. However, recruits in better aerobic fitness may also benefit from lower ARI incidence and possibly reduced symptom severity and or duration should they become ill.

This study takes advantage of a preexisting dataset to investigate the relationship between ARI, smoking history, and fitness of a gender integrated BCT population. The recruit study participants are from a healthy young adult population isolated in a homogenous environment with comparable work, rest, living environments and similar diets. Surveys were administered to recruits with clinically diagnosed ARI (cases) and their immediate healthy bunkmates (controls). Questions included previous BCT smoking behavior and assigned run group as part of a larger 19 question survey.

Hypothesis

This study's hypothesis is that diagnosed febrile and afebrile ARI among recruits is positively associated with smoking and negatively associated with assigned physical fitness run group.

Research Aims

To investigate the relationship between febrile ARI, afebrile ARI, combined total ARI incidence and risk factors associated with previous smoking behavior and run group in Army recruits during BCT. With febrile ARI, afebrile ARI and total ARI incidence as dependent variables, logistic regression models will be analyzed independently for potential risk factors of interest and then combined in a multivariate model to generate a final ARI risk estimate.

LITERATURE REVIEW

Acute Respiratory Infections

Acute respiratory infections (ARI) can involve the sinuses, pharynx (throat), tonsils, larynx (voice box), bronchi, and the lungs.²⁰ Infections of the respiratory system may also be characterized as upper or lower respiratory tract infections.²¹ Medical diagnosis of an upper respiratory tract infection (URTI) means the affected organs are primarily superior to the larynx and are generally self-limiting.²⁰ Lower respiratory tract infections (LRTI) such as pneumonia can develop with or without an URTI and tend to be more severe.

A wide variety of symptoms can be attributed to ARI. Some common symptoms are watery eyes, headache, nasal congestion, nasal or ear discharge, sore throat, coughing, shortness of breath, sneezing, fatigue, muscle ache, chills, and fever.² For example, cold symptoms in adults may persist up to fourteen days, but normally subside in seven to ten days.² The timing and duration of respiratory symptoms are important distinctions between colds and environmental (indoor or outdoor) allergens which can overlap symptoms.²

Transmission of ARI can occur from direct contact with bacterial or viral contaminated droplets produced from sneezing, coughing, or talking; suspended airborne droplet nuclei; and indirect contact of fomites or contaminated surfaces.^{22, 23} Indirectly, a person may introduce a pathogen into their eye, nose or by ingestion after contact with freshly contaminated hands and other fomites.²⁴

In general, most ARI are caused by viruses^{5, 19, 25, 26} with rhinoviruses and coronaviruses being the most prevalent among 200 known viral causes of the common

cold.² These common viruses follow seasonal patterns with rhinoviruses peaking in the fall and spring and coronaviruses most common during the winter months.^{19, 25, 26} Adenoviruses are of particular concern to military training environments because such viruses are generally reported less in the public and can be found year round.²⁵ Without prior pathogen exposure, the adaptive immune response would be less timely and increase ARI susceptibility.

BCT Medical Care

At Fort Jackson, recruits seeking medical care for illness are generally first seen by a medic at the Battalion Aid Station. Based on symptoms/temperature the recruit may be sent to see a medical provider at the Troop Medical Clinic (TMC). When the TMC is closed for the evening and on weekends, a recruit with potential ARI complications may be taken by cadre directly to the base hospital emergency department. Medical encounters are electronically recorded into a recruit's medical record by the attending provider. Generally, the clinical diagnosis is determined without laboratory confirmation with exception of the rapid Group A Streptococcus and pneumonia. Since each medical diagnosis is annotated into the respective medical record by ICD-9 code, routine medical surveillance of ARI cases during BCT are easily retrievable within the U.S. Army Public Health Command's Acute Respiratory Disease Surveillance office.

Upon completion of the recruit exam, the medical provider either specifies the recruit return to immediate duty, be admitted to medical quarters without medical attendance, or referred for follow-on care at the base hospital. Medical providers partly base their decision of returning a recruit to immediate duty verses medical quarters based upon the presence or absence of a fever. Recruits with an oral temperature $\geq 100.4^{\circ}\text{F}$,

respiratory symptoms, or any diagnosis of pneumonia are classified as febrile ARI cases and admitted to medical quarters overnight.²⁷ Recruits with respiratory symptoms, but without a fever are identified as afebrile ARI cases and are generally returned to training.²⁷

Smoking Risk Factor

The risk of ARI from exposure to active and passive cigarette smoke is perhaps less appreciated by smokers than the chronic health risks of lung cancer, cardiovascular or pulmonary diseases. This could be in part because smokers may regard mild respiratory symptoms as normal.¹² Some smokers may think smoking occasionally or a “lighter” brand cigarette is less harmful.²⁸⁻³⁰ However, there is clinical evidence that the association between ARI risk and smoking exposure is linear.^{17, 31, 32} The total exposure should account for the daily quantity smoked and the number of years a person has smoked. Researchers tend to divide smokers into light and heavy users according to the number of self reported cigarettes or pack(s) smoked per day. The exact number of cigarettes distinguishing a light, moderate, or heavy smoker is not well defined in peer-reviewed literature.

The way cigarette smoke increases risk of microbiological infections can largely be attributed to structural changes in the respiratory system and decreased immunological function.³³⁻³⁵ The cilia lining the lower respiratory tract allows for active transport of mucus and foreign particles out of the lungs. Healthy cilia normally beat around a 1,000 times per minute.³³ Cilia damaged by smoking are less mobile and prevent normal pathogen clearance from the lungs.³³ Foreign particles and pathogens that would normally be expelled from the lungs via healthy cilia are instead allowed to accumulate

and contribute to ARI. For example, in an animal study, mice exposed to four hours of cigarette smoke following *Staphylococcus aureus* inhalation showed 50% reduction of bacterial clearance.³⁶ Although slow, improvements of mucociliary function in humans can be reversed, thus allowing normal respiratory clearance of foreign particles and pathogens. Improvement of mucociliary function in humans after smoking cessation was not rapidly apparent after a week, but did show improvement in most subjects three months after smoking cessation.³⁷

In addition to the health of the lung cilia, another popular theory regarding altered immune function from cigarette smoke has focused on salivary antibodies. Temporary reductions of salivary antibodies have been suggested as a mechanism that may contribute to increased risk of ARI.^{38, 39} Saliva helps protect the mouth and respiratory mucosal surfaces from harmful pathogens with immunoglobulin (Ig) A crossing mucosal membranes to reduce pathogenic attachment and replication before colonization as well as neutralize toxins.³⁸

Smoking and ARI Epidemiological Evidence

Epidemiological investigations have shown military service members who actively smoke are at greater risk of developing ARI.¹³⁻¹⁵ Also, among military training populations, smoking has been strongly associated with outbreaks of pneumonia¹⁶ and influenza.^{40, 41} During 13 weeks of combined basic and advanced U.S. Army Infantry training, ARI received the highest number of medical diagnoses in a cohort of 649 trainees.⁴² One significant risk factor for seeking medical care of any kind was having smoked within 6 months prior to beginning training.

Smoking was the number one independent risk factor for invasive pneumococcal disease among a population based case-control study of three metropolitan centers (Atlanta, Baltimore, Toronto) conducted in 1995.¹⁷ Current smokers as well as passive smokers were associated with cases of invasive pneumococcal disease isolated as *Streptococcus pneumoniae*; linear associations were observed in each category of smoking (cigarettes smoked per day, pack-years smoked, time since cessation, and hours per day exposure to environmental tobacco smoke).¹⁷ The adjusted population attributable risk was 51% for current smokers and 17% for passive smokers.¹⁷

Smoking and ARI Clinical Evidence

Increased cold symptoms have been reported after smoking cessation. For example, mouth ulcers, sore throat, cough, and sneezing have been reported from smoking cessation subjects wearing a nicotine patch.⁴³ Recruits who smoke right up until the start of BCT may temporarily experience similar symptoms which may coincide with impaired immune function.

Increased cold symptoms following smoking cessation could be the result of an acute transient state of salivary immunoglobulin A (S-IgA) level.^{31, 38, 39, 43} When smokers and nonsmokers were age and gender-matched in a smoking cessation study, smoker S-IgA slightly decreased on day seven, but returned to normal levels of S-IgA by day fourteen.⁴³

In a study by Ertel et al., selected bacteriological pathogens showed Gram-negative bacilli were more tolerant of tobacco smoke from mentholated and nonmentholated cigarettes over Gram-positive cocci.⁴⁴ The same study followed up by culturing high numbers of Gram-negative coliforms from the mouths of several smokers with similar

results.⁴⁴ Ceasing inhalation of tobacco smoke combined with a sudden lowering of S-IgA may therefore afford oral bacteria along with other possible respiratory pathogens the opportunity to proliferate.

More importantly, S-IgA and S-IgM levels for smokers, ex-smokers, head/neck tumor patients have revealed significant reductions of S-IgA and higher S-IgM in comparison to non-smokers.³¹ This result was demonstrated in both unmatched and matched age and gender studies.³¹ The later study was also conducted in a non-drinking adult population (Cairo, Egypt) to control for possible confounding of heavy alcohol consumption. A clear S-IgA dose-response relationship was observed extending from healthy smokers (lowest IgA mean concentration of 115 ug/ml), 2 years post smoking cessation (mean concentration of 135 ug/ml) and 5 years post cessation (mean concentration of 170 ug/ml).³¹ This strong inverse correlation between S-IgA concentration and smoking was most apparent when 10 or more cigarettes per day were smoked.³¹

Smoking Demographics

Several studies have associated smoking behaviors with race, gender, age, and education. In a study of the greater St. Paul-Minneapolis area white smokers tended to smoke more cigarettes per day while blacks tended to smoke fewer but higher tar content cigarettes.⁴⁵ Also, the study shows that men are more frequently smokers when compared to women and people without a high school diploma are more frequently smokers when compared to those with higher education⁴⁵

Investigations of race and gender of the entire 1995 Air Force Basic Military Training (BMT) population (n=32,144) also observed smoking and cessation patterns

associated with race and gender.⁴⁶ In this study, 25% of the entire population reported smoking until the start of BMT, and had smoked on average for 4 years.⁴⁶ Among all active smokers white females reported the highest prevalence of smoking.⁴⁶ Hispanics were more likely than all other races to quit smoking at least the month prior to BMT.⁴⁶

Smoking Cessation and Perceived Stress

In one study of adult smokers, smoking cessation was associated with increased physical and emotional stress that abated over the course of a month. Added physical stress was reported as increased coughing, headache, dizziness, and nausea along with added emotional stress from increased feelings of anger, anxiety, irritability, restlessness, depression, and poor concentration.⁴⁸ Likewise, older recruits who previously smoked for longer periods may experience similar added physical and emotional stress temporarily at BCT.

Army Physical Training

The purpose of a standardized Army physical training (PT) program is to “improve physical fitness while minimizing injuries, progressively condition and toughen soldiers, and to develop the soldier’s self confidence and discipline”.⁴⁹ The Army standards of physical training embrace the core components of strength, endurance, and mobility.⁴⁹ Military personnel must be able to perform under high and low intensity physical activities, sometimes for prolonged periods. Such physical demands require a carefully designed training program that can physically simulate challenging battlefield situations without degradation of health or harm from injury.

BCT Physical Training

During BCT, recruits are matched to an appropriate exercise run pace group to promote optimal aerobic conditioning. Determination of run group is based upon a recruit's initial 1-mile run time during a physical fitness test conducted the first week of BCT. Four gender integrated run groups are created within each training company (150-250 recruits). The run groups are arranged from the fastest group (A) to the slowest group (D) of approximate equal size. The run pace and distance of each run group is conducted in accordance of a standardized cadre supervised training schedule. The running standards were created to minimize preventable injuries caused by excessive run mileage and frequency as well as to condition the recruits for satisfactory completion of the Army Physical Fitness Test (APFT) by the end of BCT.⁵⁰

The key factors included in the establishment of BCT run groups were: limiting the total BCT run mileage (25 miles) for groups C and D; no more than 30 minutes of run time at a frequency of three days per week for all run groups; maintaining running speeds between 70% and 80% maximal oxygen uptake (VO₂max); allowing room for increases of aerobic endurance; ensuring slower runners of each run group can keep the pace, of the fastest runners; and age and gender adjusted to pass the 2-mile APFT required to graduate training.⁵⁰ Run group C times are designed to achieve the slowest male required APFT 2-mile run time and group D to achieve the slowest female required APFT 2-mile run time.⁵⁰

Physical Training and ARI Epidemiological Evidence

Epidemiological studies of marathon runners have supported increased self reported URTI while actively training for a marathon⁵¹, after participation in marathon as well as

ultramarathon race events^{51, 52} and from increased training run mileage.⁵¹⁻⁵³ However in a separate study, recreational runners (< 15 mile/wk) participating in either a 5K or 10K road-race tended to self-report higher incidence of illness in comparison to fitness runners (> 15 mile/wk) participating in the half-marathon. Fitness runners also reported higher training run frequencies, greater number of high intensity days and ran more mileage in comparison to recreational runners.⁵⁴ Thus, the overall conclusion was regular running could possibly boost immunity directly by increased “immune surveillance” and indirectly by lowered stress from regular exercises. Nieman, hypothesized exercise may share a “J curve” relationship with URTI.¹⁹ Thus, optimal immune function may be suggested at moderate exercise workloads as opposed to extremely high and low exercise workloads.¹⁹

Physical Training and ARI Clinical Evidence

There are several aspects of immune function that can be measured in response to exercise. S-IgA concentration, plasma counts of leukocytes, neutrophils, lymphocytes, interleukins, along with stress hormones like epinephrine and cortisol have been measured in previous studies.^{19, 55, 56}

Studies of salivary immunoglobulin A levels (S-IgA) comparing before and after various exercise activities have also shown reductions of S-IgA by 42% after prolonged 90 minute consecutive days of treadmill running⁵⁷ and a 52% reduction in S-IgA flow rate of saliva after acute high intensity training.⁵⁸

A direct comparison in immune function between female and male athletes has concluded no substantial difference of URTI risk in one study.⁵⁵ However, women were observed to have a statistically significant lower S-IgA concentration and B cell count; it

was unknown if this was clinically meaningful or if it represented lowered immunity because these are isolated biomarkers that do not account for overall immune function or normal variation.⁵⁵ It was reported that the “training load” could cause women to experience greater sensitivity to S-IgA and B cell counts in comparison to males.⁵⁵

Physical Training Demographics

Physical fitness is the compilation of many physical attributes that effect physical activity performance.⁵⁹ Depending on the type of physical activity required, various physical attributes such as cardio-respiratory function, oxygen transport and delivery, neuromusculo-skeletal function and psychological drive may be required at any one time.⁶⁰ Many physical attributes can be influenced by many modifiable behaviors such as regular exercise, proper diet, smoking, etc; on the other hand, differences in a person’s age and gender cannot be modified and allow for further differences in physical performance.

Generally, physical performance has shown to decline with age; however, regular physical training has been shown to minimize declining physical performance normally associated with aging.⁶¹ Physical training associated with run frequency and/or run duration in the U.S. Army has shown strong correlations with improved APFT run time across all age groups.⁶¹ Thus, older physically active recruits who perform regular running prior to BCT may stand an equal chance of being assigned to a higher run group compared to younger recruits.⁶¹

It is recognized that on most aspects of physical fitness, females tend to have lower absolute physical performance when compared to males.⁶² Therefore, most females have a higher relative exercise intensity (%VO₂max), when performing physical activities

alongside male recruits. Such gender integrated training activities may include physical exercise, tactical and non-tactical road marches, live-fire exercises, confidence courses, obstacle courses, land navigation, etc.

Physical Training and Smoking

Epidemiological studies have associated cigarette smoking with sedentary lifestyle or low physical activity.⁶³ In the military however, higher smoking prevalence among physically active individuals has been observed.⁶³ In the survey conducted of the entire 1995 Air Force Basic Military Training (BMT) recruit population (n=32,144), 21% perceived themselves as being more physically active than their peers and another 52% indicated they shared the same amount of physical activity as their peers.⁶³ In comparison to nonsmokers, smokers less often reported being more physically active than their peers (16% vs 23% respectively).⁶³

Previous studies have not supported decreased aerobic capacity resulting from cigarette smoking in young adult populations.^{62, 64, 65} Thus, smoking status should not affect recruits assigned run group given the youth of this population.

Klesges et al., tested the hypothesis that smoking can effect body weight among a young adult population of Air Force recruits.⁶⁶ In this study, body weight was compared across smokers, experimental smokers, and nonsmokers and found regular current male smokers had a one kilogram reduction in weight.⁶⁶ However, a dose-response relationship between weight control and previous smoke exposure was not observed. Among female recruits no statistical difference in weight was observed between smokers and nonsmokers.

Physical Training and Perceived Stress

In athletes and nonathletic populations research has shown an association between increased stress and URTI symptom severity and duration.^{9, 52, 54, 67} Powerful hormones in response to exercise such as cortisol and epinephrine have been associated with reduced immune function.⁶⁷ Epinephrine and cortisol were elevated in subjects after 2.5 hours of treadmill running at 75% VO₂max.⁵⁶

Healthy adults administered nasal drops containing live cold viruses (rhinovirus type 2, 9, 14; respiratory syncytial virus, coronavirus type 229E) showed a positive linear association between ARI and psychological stress.⁹ After accounting for the standard control variables (serologic status, age, gender, education, allergic status, weight, season, number of subjects in the house or other ill subjects present in the house), health practices (smoking, alcohol consumption, exercise, quality of sleep and diet), measured personality styles (self-esteem, personal control, and introvert-extrovert), and immune function (white-blood cell and total immunoglobulin counts) a higher psychological-stress index was associated with clinically diagnosis colds (adjusted OR (high/low index)=2.2) and positive virus-specific antibody confirmation infections (adjusted OR (high/low stress index)=5.8).⁹

Physical training encompasses both physical and mental aspects of stress.⁶⁷ For example, not all runners are physically built for sprinting and long distance endurance racing. Thus, a well conditioned sprinter may emotionally perceive running a marathon equally challenging as a first time marathon runner. Recreational runners tend to run at comfortable distances and intensities, competitive athletes intentionally train under frequent strenuous (intensity and duration) periods to build physical stamina.

Additionally, competitive athletes contend with added emotional stressors (personal, peer, and environmental pressures) resulting from the race/sporting event itself.^{51, 52, 67} Physical fitness testing during BCT could represent heightened emotional stress for some recruits worried about achieving weight standards and or satisfactory scores.

Peters and Bateman observed ultramarathon runners increased URTI symptoms were associated with completed race time.⁵² Incidences of URTI ranged from 19% (completion in 5.5 to 6 hours) to 47% (completion in < 4 hours).⁵² The researchers hypothesized the faster racers suffered more URTI because of greater competitive drive as well as from increased physical effort.⁵²

Recruits with less athletic ability or state of poor physical fitness condition may self report greater physical and emotional stress during BCT. Female recruits may also perceive greater physical and emotional stress because of a slight physical disadvantage compared to males.^{64, 65, 68}

SUBJECTS AND METHODOLOGY

Institutional Review Board

The data used in this study was from a previously approved IRB. All subjects of the previous study provided written consent. A de-identified version of the original data set was derived for use in this study. Approval for this data analysis was granted by the Office of Research, Uniformed Services University of The Health Sciences (USUHS).²⁷

Subjects and Study Design

Data for this ARI study were collected from U.S. Army recruits attending consecutive nine week intervals of BCT at Fort Jackson, South Carolina, February

through May 2004. The ARI surveys (long and short versions) comprised of the primary risk factors of smoking history and run group (Appendix i). The short survey version does not capture repeat demographic information previously answered by the same recruit. The surveys were administered to ARI cases following medical examination and healthy bunkmate controls within two weeks of ARI diagnosis. Cases of ARI were identified by the recruit's medical record and linked to a unique survey identification number. During the final week of training cases were captured through BCT graduation, but without surveyed controls. Cases of ARI were originally collected from the BCT medial quarter admissions and the Moncrief Army Community Hospital databases. The de-identified electronic dataset was comprised of 2,284 surveys. All subjects must have completed a survey and resided in a 60 person capacity barracks bay. Surveys with missing information on variables of interest were excluded from the study.

Case Definition

Cases of ARI were identified by medical record with one or more of the following ICD-9 codes: upper respiratory infection of unspecified site (465.9), acute bronchitis (466.0), unspecified viral infection (079.99), acute pharyngitis (462), acute tonsillitis (463), pneumonia (486.0), streptococcal sore throat (034.0), and acute nasopharyngitis (460.0). Data sources were from the medical quarter barracks admission data base and the Moncrief Army Community Hospital Ambulatory data system.²⁷

Diagnosed ARI cases were further stratified into febrile (fever) and afebrile outcomes. Febrile ARI is based on the U.S. Army Acute Respiratory Disease definition of having an oral temperature $>100.4^{\circ}$ F or 38° C; and respiratory symptoms; or any diagnosis of pneumonia.²⁷ Febrile cases (n=415) were comprised of having a clinic visit

and were admitted to medical quarters (Table 1). Afebrile cases (n=669) were identified by a documented clinical visit with or without a medical quarters admission.

Control Definition

Controls surveyed (n=1,200) were healthy recruit bunkmates immediately surrounding each respective ARI case (possible left or right bunk beds and top or bottom bunk). Controls had no clinic visit or admission to medical quarters for ARI (Table 1).

Risk Factor Definitions

Smokers were identified as having smoked 100 cigarettes (*five packs*) in their life time (Question 12, Appendix i). Smoking behavior was collapsed into the number of daily packs smoked (*never smoked* and *not regularly*, ≤ 0.5 , > 0.5) prior to BCT (Question 14, Appendix i). Time since smoking cessation prior to entering BCT was collapsed into one of the following: *never smoked* or *never regularly*; ≥ 1 year; or < 1 year (Question 13, Appendix i). Exercise run groups (*A-fastest*, *B*, *C*, *D-slowest*) were assigned by cadre based on the recruit's initial 1-mile run time established within the first week of BCT (short survey, Appendix i). Run group B was used as the referent for the females because of so few females were assigned to run group A. Body mass index (BMI) was calculated from self reported height and weight using the formula: (weight in pounds / height in inches) x 703 = kg/m^2 (Appendix i). Stratification of BMI was based on the National Institute of Health cut points for underweight ($< 18.5 \text{ kg/m}^2$), normal weight ($18.5\text{-}24.9 \text{ kg/m}^2$), overweight ($25.0\text{-}29.9 \text{ kg/m}^2$), and obese ($> 30 \text{ kg/m}^2$).⁶⁹ Self reported stress experienced from BCT was evaluated separately for emotional and physical stress on a four point scale (Questions 16 and 17, Appendix i). Demographics included age, gender and race. Age was calculated from the arbitrary mid study date of 1 March 2004

subtracted from the recruit's reported date of birth. Recruits self reported race (Question 5, Appendix i) was reduced to Black, Hispanic, White and Other with other including unspecified, Native American and Pacific Islander.

Statistical Analysis

Demographics of age, gender, race, previous smoking behavior and assigned run group were captured by frequency count and percentages. Descriptive physical characteristics (mean, range and standard deviation) were included for age, height, weight, and BMI.

The expected and observed minimal detection difference of 25% was not different from original sample size calculations when recalculated based on the actual number of cases (n=1,084) and controls (1,200) assuming 80% power at the alpha level of 0.05. Data analysis was performed using IBM SPSS Statistics v 20.0 software (IBM SPSS Statistics, Chicago, IL).

Univariate logistic regression models were used to estimate the unadjusted odds ratio (OR) and a 95% confidence interval (95% CI) for each of the selected independent variables (≥ 100 cigarettes smoked in lifetime, packs/day, time since smoking cessation, perceived physical stress, perceived emotional stress, run group, BMI, age, gender, and race). Dependent variables included febrile ARI, afebrile ARI and a combined total ARI.

Gender-specific multivariate logistic regression (LR) models were used to estimate the adjusted OR and 95% CI using a backward stepwise selection method. Primary independent variables of interest, run group and packs/day, were kept in multivariate models regardless of statistical significance. Multivariate regression models

were constructed for each of the dependent variables of febrile ARI, afebrile ARI and a total ARI.

RESULTS

The total number of participants for this study was comprised of 2,284 U.S. Army BCT recruits (Table 1). The total number of ARI cases (febrile and afebrile cases) was comprised of 1,084 recruits with a comparative control population of 1,200 recruits for a case-control ratio of approximately 1:1 (Table 1).

Table 1. Case-Control Frequencies of Subjects

ARI Cases-Controls	Frequency Count
Controls	1,200
Febrile cases	415
Afebrile cases	669
Total Cases and Controls	2,284

Recruit demographics were reported by count and percent total for the respective demographic subgroup (Table 2). Percent ARI cases (febrile and afebrile) and percent controls was included for each subgroup. This cohort was comprised of 50% 20-24 year olds, 63% males, and 56% whites (Table 2).

Table 2. Demographics of Subjects

Selected Demographics				
N= 2,284	n	(%)	% Cases	% Controls
<i>Age group (years)</i>				
< 20	716	(31)	33	30
20 - 24	1,150	(50)	51	50
25+	418	(18)	16	20
<i>Gender</i>				
Male	1,437	(63)	63	62
Female	847	(37)	37	38
<i>Race</i>				
Black	463	(20)	21	20
Hispanic	307	(13)	12	15
White	1,283	(56)	58	55
Other	231	(10)	10	10

Percentages may not equal total 100 due to rounding.

Along with the primary risk factors of packs/day and run group, five additional risk factors of having ever smoked ≥ 100 cigarettes in a lifetime, time since smoking cessation of BCT entry, BMI, physical stress, and emotional stress were analyzed (Table 3). Almost 50% had ever smoked ≥ 100 or more cigarettes in life time with 37% having smoked daily. The run groups appeared to be normally distributed with the slowest run group comprising the smallest percentage (9%) (Table 3). Over half (62%) of the recruits reported being normal to underweight by the National Institute of Health's classification of BMI of $< 25 \text{ kg/m}^2$. Emotional and physical stressed of BCT was most often reported as slightly difficult (37% and 46% respectfully) (Table 3).

Table 3. Risk Factor Characteristics

Selected Factors		
<i>N= 2,284</i>	<i>n</i>	<i>(%)</i>
<i>≥ 100 Cigarettes smoked</i>		
No	1,251	(55)
Yes	1,033	(45)
<i>Cigarette packs per day</i>		
Never smoked/ never regularly	1,424	(62)
≤ 0.5	374	(16)
> 0.5	486	(21)
<i>Time since cessation</i>		
Never smoked	1,251	(55)
≥ 1 year	142	(6)
< 1 year	891	(39)
<i>Run group (time per 1 mile)</i>		
A - fast (7:15 and faster)	548	(24)
B - moderate (7:16 to 8:15)	895	(39)
C - slow (8:16 to 10:15)	633	(27)
D - slowest (10:16 and slower)	208	(9)
<i>Body mass index (kg/m^2)</i>		
Under and normal weight (<25)	1,423	(62)
Overweight (25 to 30)	730	(32)
Obese (> 30)	131	(6)

<i>Physical stress</i>		
Not difficult	491	(22)
Slightly difficult	1,052	(46)
Difficult	494	(22)
Very difficult	247	(11)
<i>Emotional stress</i>		
Not difficult	741	(32)
Slightly difficult	846	(37)
Difficult	389	(17)
Very difficult	308	(14)

Percentages may not equal total 100 due to rounding.

The physical characteristics of age, height, weight, and BMI were reported as mean averages, range and standard deviation while stratified by gender (Table 4). The average age was 22 years old with a range of 17-39 years. Mean height and weight was slightly increased for males with an overall population mean height and weight of 67.5 inches and 158 pounds (Table 4).

Table 4. Physical Characteristics

Total (N= 2,284)			
Measurement	Mean	Range	SD
Age (yrs)	22.0	17 – 39	3.7
Height (inches)	67.5	50 – 79	4.1
Weight (lbs)	157.7	91 – 250	28.9
BMI (kg/m ²)	24.2	14 – 44	3.4

Females (N= 847)			
Measurement	Mean	Range	SD
Age (yrs)	21.8	17-36	3.7
Height (inches)	64.2	50-74	3.1
Weight (lbs)	136.0	91-213	19.2
BMI (kg/m ²)	23.2	14-36	3.0

Males (N= 1,437)			
Measurement	Mean	Range	SD
Age (yrs)	22.0	17-39	3.7
Height (inches)	69.4	56-79	3.3
Weight (lbs)	170.3	107-250	25.5
BMI (kg/m ²)	24.9	16-44	3.5

Population demographics of age, gender and race were compared between febrile, afebrile and total ARI outcomes (Table 5). Of statistical significance, older age (25+ years) was found to be protective for febrile (OR=0.66, CI 0.47-0.91) and overall total ARI (OR=0.75, CI 0.59-0.96). There were no major differences between odds ratios across race categories and gender for ARI.

Table 5. Univariate Logistic Regression Models

ARI - Demographics			
	Febrile	Afebrile	Total
Variable	Cases: 415 Controls: 1,200	Cases: 669 Controls: 1,200	Cases: 1,084 Controls: 1,200
<i>Age</i>			
< 20	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
20 – 24	0.95 (0.74, 1.22)	0.95 (0.76, 1.17)	0.79 (0.79, 1.14)
25+	0.66 (0.47, 0.91)	0.81 (0.61, 1.07)	0.75 (0.59, 0.96)
<i>Gender</i>			
Females	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Males	0.92 (0.73, 1.16)	0.98 (0.80, 1.19)	0.96 (0.81, 1.13)
<i>Race</i>			
Black	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Hispanic	0.78 (0.53, 1.16)	0.75 (0.53, 1.06)	0.77 (0.57, 1.02)
White	0.98 (0.74, 1.30)	1.04 (0.82, 1.33)	1.02 (0.82, 1.26)
Other	0.75 (0.48, 1.18)	1.01 (0.70, 1.44)	0.91 (0.66, 1.24)

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

Univariate logistic regression models for each risk factor were conducted to compare estimated risk (odds ratios) associated with febrile, afebrile and combined total ARI (Table 6). A previous BCT smoking history suggested a linear increase of risk

associated with packs per day smoked and for smoking cessation within the year prior to entering BCT (Table 6). For febrile ARI, the odds of having smoked more than half pack/day was 1.33 (1.05-1.68) compared to the referent group. Additionally, smoking more than half a pack/day was associated with increased risk for total ARI (OR=1.33, CI 1.07-1.61) and almost statistically significant for febrile ARI (OR=1.29, CI 0.98-1.70). Time since smoking cessation was suggestive of a protective association for all ARI outcomes when smoking cessation occurred earlier than one year prior to BCT (Table 6). For total ARI the odds of cases having quit smoking earlier than the year prior to BCT were 0.86 (0.60-1.02) when compared to non-smokers. Run group and ARI odds were slightly elevated for afebrile ARI among the slower run groups in comparison to febrile ARI (Table 6). Of additional note, a linear association between run group and all ARI outcomes was observed (Table 6). No differences of ARI risk were apparent across either BMI category or ARI outcome. Lastly, self-reported high physical stress was significantly associated across all univariate ARI models (Table 6). Among total ARI the odds of very difficult perceived physical stress in cases was 1.51 (1.11-2.05) compared to controls (statistically significant). A similar, although attenuated, linear association was observed for emotional stress (Table 6).

Table 6. Univariate Logistic Regression Models

ARI Risk Factors			
	Febrile	Afebrile	Total
Variable	Cases: 415 Controls: 1,200	Cases: 669 Controls: 1,200	Cases: 1,084 Controls: 1,200
<i>≥ 100 Cigarettes smoked</i>			
No	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Yes	1.15 (0.92, 1.44)	1.12 (0.93, 1.36)	1.13 (0.96, 1.34)

<i>Pack(s) per day</i>			
Never smoked / not regularly	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
≤ 0.5	1.14 (0.83, 1.55)	1.14 (0.87, 1.48)	1.14 (0.90, 1.43)
> 0.5	1.29 (0.98, 1.70)	1.33 (1.05, 1.68)	1.31 (1.07, 1.61)
<i>Time since cessation</i>			
Never smoked	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
≥ 1 year	0.83 (0.50, 1.36)	0.88 (0.58, 1.31)	0.86 (0.60, 1.02)
< 1 year	1.21 (0.96, 1.53)	1.17 (0.96, 1.43)	1.19 (1.00, 1.41)
<i>Run group (males & females)</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
B - moderate	0.94 (0.70, 1.25)	1.03 (0.80, 1.32)	0.94 (0.80, 1.23)
C - slow	1.00 (0.74, 1.37)	1.17 (0.90, 1.53)	1.10 (0.88, 1.39)
D - slowest	1.14 (0.74, 1.76)	1.32 (0.92, 1.91)	1.25 (0.91, 1.72)
<i>Body mass index (kg/m²)</i>			
Under / normal weight (<25)	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Overweight (25 to 30)	1.08 (0.85, 1.37)	0.92 (0.75, 1.13)	0.98 (0.82, 1.17)
Obese (> 30)	1.03 (0.64, 1.68)	0.96 (0.64, 1.45)	0.99 (0.69, 1.41)
<i>Physical stress</i>			
Not difficult	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Slightly difficult	0.84 (0.62, 1.12)	1.05 (0.82, 1.35)	0.97 (0.78, 1.20)
Difficult	1.18 (0.84, 1.64)	1.12 (0.84, 1.50)	1.14 (0.89, 1.47)
Very difficult	1.54 (1.03, 2.29)	1.49 (1.05, 2.12)	1.51 (1.11, 2.05)
<i>Emotional stress</i>			
Not difficult	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
Slightly difficult	0.99 (0.76, 1.30)	1.05 (0.83, 1.31)	1.03 (0.84, 1.25)
Difficult	1.09 (0.79, 1.52)	1.05 (0.79, 1.40)	1.07 (0.84, 1.37)
Very difficult	1.15 (0.80, 1.65)	1.18 (0.87, 1.60)	1.17 (0.90, 1.53)

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

When gender was stratified for each run group, a linear dose response association between afebrile ARI risk and run group was apparent for both genders, but linearity differed between genders for febrile ARI (Table 7). Febrile ARI risk for females appeared consistently elevated across all run groups as opposed to the apparent linear relationship between run group and afebrile ARI. The observed wide confidence intervals among the females and again for males in run group D was due to the low number of runners in the respective female fastest run group and the slowest male run group.

Table 7. Univariate Logistic Regression Models for Gender Specific Run Groups

ARI Female Run Group			
	Febrile	Afebrile	Total
Variable	Cases: 148 Controls: 451	Cases: 248 Controls: 451	Cases: 396 Controls: 451
<i>Run group (females)</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
B - moderate	3.19 (0.70, 14.51)	1.36 (0.50, 3.66)	1.82 (0.75, 4.40)
C - slow	2.88 (0.65, 12.68)	1.68 (0.65, 4.34)	1.98 (0.85, 4.65)
D - slowest	3.28 (0.72, 14.87)	1.97 (0.74, 5.23)	2.30 (0.95, 5.53)
ARI Male Run Group			
	Febrile	Afebrile	Total
Variable	Cases: 267 Controls: 749	Cases: 421 Controls: 749	Cases: 688 Controls: 749
<i>Run group (males)</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
B - moderate	0.87 (0.65, 1.19)	1.04 (0.80, 1.35)	0.98 (0.78, 1.22)
C - slow	1.23 (0.78, 1.94)	1.38 (0.93, 2.05)	1.32 (0.93, 1.86)
D - slowest	3.42 (0.90, 12.97)	2.38 (0.63, 9.00)	2.81 (0.87, 9.06)

Statistical values: odds ratio (95% confidence interval).

Febrile ARI adjusted odds ratios were calculated for the primary risk factor of run group and packs/day smoked for both genders. For febrile ARI the odds of female run group D were 3.21 (0.71, 14.56) among female cases in comparison to controls, after adjusting for smoking. Male febrile ARI showed the odds of run group D cases were 3.30 (0.87-12.61) compared to controls, after adjusting for smoking. Adjusting for smoking did not appear to affect dose-response for either gender specific run group.

Table 8. Multivariate Logistic Regression Models

Febrile ARI Smoking & Run Group			
	Females	Males	Total
Variable	N = 847	N = 1,437	N = 2,284
<i>Packs per day</i>			
Never smoked /not regularly	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
≤ 0.5	1.22 (0.63, 2.36)	1.12 (0.72, 1.74)	1.14 (0.79, 1.65)
> 0.5	1.44 (0.85, 2.43)	1.20 (0.86, 1.68)	1.30 (0.98, 1.72)
<i>Run group</i>			

A – fast	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
B - moderate	1.13 (0.71, 1.80)	2.72 (0.87, 10.75)	2.10 (0.85, 8.90)
C - slow	1.01 (0.58, 1.76)	3.79 (1.00, 14.38)	2.84 (0.88, 9.15)
D - slowest	3.32 (0.71, 14.56)	3.30 (0.69 12.61)	2.75 (0.63, 6.96)

Statistical values: odds ratio (95% confidence interval).

Afebrile ARI adjusted odds ratios were calculated for the primary risk factors of run group and packs/day smoked for both genders (Table 9). For afebrile ARI a clearer linear dose response was observed for both risk factors. Of statistical importance was the finding for total combined gender febrile ARI which showed the odds of having smoked > 0.5 pack/day were 1.35 (1.07, 1.72) among cases compared to controls after adjusting for run group. Additionally, smoking > 0.5 pack/day was nearly statistically significant for both males (OR=1.25, 0.94-1.66) and females (OR=1.55, 0.99-2.40). For both genders being in the slowest run group had the highest risk. For males the odds of run group D cases were 2.38 (0.63, 9.01) compared to controls, after adjusting for smoking. For females, the odds of run group D cases were 1.95 (0.73-5.19) compared to controls, after adjusting for smoking. After adjusting for run group, likely a linear dose-response association for packs smoked per day was observed.

Table 9. Multivariate Logistic Regression Models

Afebrile ARI Smoking & Run Group			
	Females	Males	Total
Variable	N = 847	N = 1,437	N = 2,284
Packs per day			
Never smoked / not regularly	1.00 (Referent)	1.00 (Referent)	1.00 (Referent)
≤ 0.5	1.34 (0.77, 1.78)	1.15 (0.78, 1.51)	1.20 (0.88, 1.64)
> 0.5	1.55 (0.99, 2.40)	1.25 (0.94, 1.66)	1.35 (1.07, 1.72)
Run group			
A – fast	1.00 (Referent)	1.00 (Referent)	
B - moderate	1.16 (0.79, 1.69)	2.38 (0.63, 6.75)	
C - slow	1.47 (0.90, 2.38)	2.29 (0.61, 8.63)	
D - slowest	1.95 (0.73, 5.19)	1.73 (0.45, 9.01)	

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

Total ARI adjusted odds ratios were calculated for the primary risk factors of run group and packs/day smoked for both genders (Table 10). For total ARI the smoking risk factor associated with the number of packs/day smoked appeared almost statistically significant for both genders. For females, the odds of cases that smoked > 0.5 pack/day were 1.50 (1.02, 2.21) compared to controls after adjusting for run group. For males, the odds of cases that smoked > 0.5 pack/day were 1.23 (0.96-1.58) compared to controls after adjusting for run group. The same linear dose response was observed for both gender run groups; however, the female run group risk estimates appeared to be somewhat elevated for run groups B and C compared to males (Table 10). The wide confidence intervals among all female run groups and the slowest male run group were the result of sparse data within Group A for females and Group D for males. Adjusting for run group / packs/day did not appear to largely affect the linear dose response.

Table 10. Multivariate Logistic Regression Models

Total ARI Smoking & Run Group			
	Females	Males	Total
Variable	<i>N</i> = 847	<i>N</i> = 1,437	<i>N</i> = 2,284
<i>Packs per day</i>			
Never smoked / not regularly	1.00 (Referent)	1.00 (Referent)	
≤ 0.5	1.29 (0.79, 2.10)	1.14 (0.82, 1.58)	
> 0.5	1.50 (1.02, 2.21)	1.23 (0.96, 1.58)	
<i>Run group</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	
B - moderate	1.14 (0.81, 1.60)	2.10 (0.63, 6.96)	
C - slow	1.27 (0.84, 1.92)	2.84 (0.88, 9.15)	
D - slowest	2.27 (0.94, 5.47)	2.75 (0.85, 8.90)	

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

The final gender stratified febrile ARI multivariate regression model included the forced risk factors of packs per day and run group along with physical stress and age (Table 11). After adjustment for all of the respective risk factors, among cases who smoked > 0.5 pack/day compared to controls, female cases appeared to have a slightly elevated risk (OR=1.38, 0.81-2.35) compared to males who smoked more than 0.5 packs per day (OR=1.20, CI 0.86-1.68), as well as an elevated risk for the run group B (OR=3.00, CI 0.65-13.74) and run group C (OR=2.51, CI 0.56-11.22). Physical stress and age were both suggestive of a linear protective association for both genders (Table 11). Physical stress for females appeared to be a statistically significant risk factor for the categories of difficult (OR=2.01, CI 1.18-3.42) and very difficult physical stress (OR=2.34, CI 1.12-4.88) (Table 11). The odds among female cases aged 25 years and older were 0.55 (CI 0.31-0.99) compared to controls after adjustment for all other risk factors. Age was significant at the age category of 25+ years when both genders were combined (OR=0.64, CI 0.45-0.90).

Table 11. Final Multivariate Logistic Regression Models

Febrile ARI			
	Females	Males	Total
Variable	N = 847	N = 1,437	N = 2,284
<i>Packs per day</i>			
Never smoked /not regularly	1.00 (Referent)	1.00 (Referent)	
≤ 0.5	1.16 (0.60, 2.26)	1.05 (0.67, 1.68)	
> 0.5	1.38 (0.81, 2.35)	1.20 (0.86, 1.65)	
<i>Run group</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	
B - moderate	1.05 (0.65, 1.71)	2.60 (0.65, 11.88)	
C - slow	0.88 (0.49, 1.60)	3.52 (0.91, 13.64)	
D - slowest	2.65 (0.57, 12.31)	3.02 (0.77, 11.88)	
<i>Physical stress</i>			
Not difficult	1.00 (Referent)	1.00 (Referent)	
Slightly difficult	1.60 (0.90, 2.82)	1.12 (0.63, 2.01)	

Difficult	2.01 (1.18, 3.42)	1.70 (0.98, 2.94)	
Very difficult	2.34 (1.12, 4.88)	1.32 (0.74, 2.36)	
Age			
< 20	1.00 (Referent)	1.00 (Referent)	
20 – 24	0.64 (0.37, 1.12)	0.71 (0.47, 1.07)	
25+	0.55 (0.31, 0.99)	0.67 (0.44, 1.05)	

Statistical values: odds ratio (95% confidence interval).

Bolded means significance $p \leq 0.05$.

The final model afebrile ARI multivariate logistic regression analysis did not add any further risk factors beyond the forced packs per day and run group for either female or male models (Table 12).

Table 12. Final Multivariate Logistic Regression Models

Afebrile ARI			
	Females	Males	Total
Variable	<i>N</i> = 847	<i>N</i> = 1,437	<i>N</i> = 2,284
<i>Packs per day</i>			
Never smoked / not regularly	1.00 (Referent)	1.00 (Referent)	
≤ 0.5	1.34 (0.77, 1.78)	1.15 (0.78, 1.51)	
> 0.5	1.55 (0.99, 2.40)	1.25 (0.94, 1.66)	
<i>Run group</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	
B - moderate	1.16 (0.79, 1.69)	2.38 (0.63, 6.75)	
C - slow	1.47 (0.90, 2.38)	2.29 (0.61, 8.63)	
D - slowest	1.95 (0.73, 5.19)	1.73 (0.45, 9.01)	

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

The final total ARI multivariate logistic regression model suggested the following risk factors of physical stress, age, and BMI were important along with the forced risk factors of packs/day and run group (Table 13). Among females, run groups B (OR=1.69, 0.69-4.14) and C (OR=1.87, 0.79-4.46) were elevated in comparison to their male run group counterparts (Table 13). Physical stress remained a statistically significant risk factor at the slightly difficult (OR=1.78, 1.03-3.06), difficult (OR=1.60, 1.06-2.42) and very difficult (OR=1.29, 0.83-1.99) stress categories. Males almost shared equal

significances at the age category of 25 years and greater (OR=0.76, CI 0.56-1.05) along with females (OR=0.63, CI 0.42-0.95). Additionally, BMI appeared as a significant protective association for females. Odds of obesity were 0.33 (0.12-0.96) among cases compared to controls, after adjustment to all risk factors. For female recruits, being 25 years and older was protective (OR=0.63, CI 0.56-0.91). Males aged 25 years and older were similar and nearly statistically significant (OR=0.76, CI 0.56-1.05).

Table 13. Final Multivariate Logistic Regression Models

Total ARI			
	Females	Males	Total
Variable	N = 847	N = 1,437	N = 2,284
<i>Packs per day</i>			
Never smoked / not regularly	1.00 (Referent)	1.00 (Referent)	
≤ 0.5	1.24 (0.76, 2.03)	1.13 (0.81, 1.58)	
> 0.5	1.46 (0.98, 2.16)	1.24 (0.97, 1.59)	
<i>Run group</i>			
A – fast	1.00 (Referent)	1.00 (Referent)	
B - moderate	1.15 (0.80, 1.64)	2.05 (0.62, 6.89)	
C - slow	1.27 (0.81, 2.00)	2.69 (0.82, 8.76)	
D - slowest	2.16 (0.87, 5.34)	2.57 (0.78, 8.49)	
<i>Physical stress</i>			
Not difficult	1.00 (Referent)	1.00 (Referent)	
Slightly difficult	1.78 (1.03, 3.06)	1.35 (0.86, 2.12)	
Difficult	1.60 (1.06, 2.42)	1.44 (0.95, 2.19)	
Very difficult	1.29 (0.83, 1.99)	1.31 (0.84, 2.05)	
<i>Age</i>			
< 20	1.00 (Referent)	1.00 (Referent)	
20 – 24	0.75 (0.51, 1.12)	0.79 (0.59, 1.05)	
25+	0.63 (0.42, 0.95)	0.76 (0.56, 1.05)	
<i>Body mass index</i>			
Under / normal weight (< 25)	1.00 (Referent)	1.00 (Referent)	
Overweight (25 to 30)	0.42 (0.03, 1.25)	1.06 (0.61, 1.81)	
Obese (> 30)	0.33 (0.12, 0.96)	1.15 (0.77, 1.74)	

Statistical values: odds ratio (95% confidence interval).

Bolded means significant $p \leq 0.05$.

DISCUSSION

Overall, a positive linear association between packs/day previously smoked before BCT entry and ARI risk was observed. Univariate logistic regression models found smoking > 0.5 pack/day to be positively associated with all ARI outcomes with the exception of febrile ARI which was very close to statistical significances (OR= 1.29, 0.98-1.70). This suggests that recruits who previously smoked more than a 0.5 pack/day could be at an elevated risk for ARI.

Run group also appeared to show a linear association with ARI risk during univariate analysis with the slowest run group (D) having the highest risk (Table 6). Because run groups are gender integrated, potential biological differences in run time were anticipated to be associated with gender. After stratifying ARI by gender in separate univariate logistic models, each run group was evaluated for each ARI outcome. A generally linear association between run group and ARI risk was also observed for each gender (Table 7) suggesting trainees who are more aerobically fit entering Basic Combat Training are at lower risk for developing ARI during training.

The risk factors of packs per day and run group were next evaluated together in a separate multivariate logistic regression model for each ARI outcome (Tables 8-10). No difference in odds ratios ($\pm 10\%$) for smoking or run group was observed when comparing univariate and multivariate models, suggesting these risk factors are independent.

The smoking risk factor of packs/day did not appear to be confounded with run group as the difference between the unadjusted and adjusted odds ratios while controlling for run group were less than ten percent. This is in agreement with previous literature suggesting cigarette smoking history does not tend to have a significant role on aerobic

fitness in younger aged populations.^{62, 64, 65} Therefore, run group and a smoking history (packs/day) were both considered in all future multivariate analysis models.

The univariate analysis for time since smoking cessation and ARI was stratified by greater than or less than a year prior to entering BCT and was suggestive of a dose response relationship (Table 7). Though smoking history was never a significant risk factor, the analysis does support the hypothesis that earlier smoking cessation prior to entering BCT may have added benefit in lowering ARI risk among previous smokers.

During the final multivariate logistic regression models, backward stepwise model selection was conducted. Forcing packs per day into each ARI model and adjusting for all other risk factors, packs per day was never statistically significant (Table 13), but continued to show a persistent positive linear association across febrile, afebrile and total ARI models (Table 11-13). Regardless of significance, packs per day smoked previous to BCT were considered an important risk factor for ARI because some negative smoking effects may still persist for some time after cessation.^{31, 37-39}

The general association between ARI risk and run group did not appear to follow the J-shape risk curve as previously reported in literature.¹⁹ Rather, a linear dose-response relationship was observed between run group and ARI risk with the slower run groups generally suggestive of higher ARI risk. Sparse data for females in the referent fastest run group resulted in large confidence intervals being observed. One alternative could have been to collapse the run groups into two run groups (A and B) and (C and D). However, this may have masked the effect in sparse groups making it harder to interpret which were at higher/lower ARI risk with no ability to evaluate a linear association.

Selecting another reference group could also have been conducted, but this would have made comparison across gender less obvious.

The most consistent finding regarding run group and ARI risk in general was that slower run groups generally were associated with higher ARI risk. Additionally, based on run group gender stratification in both univariate and multivariate models, females appeared to show less linearity across the run groups but stronger positive associations suggesting they were more vulnerable to ARI risk in general (Tables 7, 11, and 13).

Females again appeared to be more sensitive to physical stress as statistical significance and strong linearity appeared in both univariate (Table 6) and multivariate models of febrile and total ARI (Tables 11 and 13). Heightened physical stress may have resulted from some recruits arriving to BCT at a lower level of physical fitness.

Age was shown to have a linear protective effect for ARI risk during univariate and multivariate febrile and total ARI models (Tables 5, 11 and 13). Likewise, recruits aged 25+ years and older were routinely statistically significant for all ARI outcomes. The risk among those 25+ years of age were 0.73 (0.56-0.93) compared to trainees younger than 20 in the univariate model. Older recruits may be more likely to have been parents living in more crowded environments with young children prior to BCT or previously lived in a crowded school dormitory settings allowing for increased acquired immunity from previous common ARI exposures. Additionally, older recruits may possess more general health knowledge and consistency of practicing good personal hygiene habits over younger recruits.

The finding that elevated BMI/obesity was significantly protective (OR=0.33, CI 0.12-0.96) among females was unexpected (Table 13). One potential explanation may be

that some female recruits may have had children within the past year and are slow to remove the added pounds. Alternatively, some females may perceive smoking as a form of weight control and partly confound the real ARI risk associated from increased BMI.

CONCLUSION

Strengths

ARI in a BCT population allows the opportunity to study potential disease patterns in a short time across a large recruit population sharing comparable homogeneous external factors such as regimented sleep, physical activity and comparable diet. Increased medical access, timely survey follow up, and clinical diagnosis of ARI brings strong validity to this study.

Limitations

Recognized potential limitations are as follows: 1) The de-identified ARI dataset was previously collected; 2) The ARI survey questions may contain self reporting biases; 3) The International Classification of Disease version 9 (ICD-9) codes previously chosen may not capture all possible ARI cases; 4) Medical providers may show preference for particular ARI ICD-9 codes; 5) Recruits may have different health seeking behaviors between units based on cadre control.

Implications

Based on the risk factors investigated, ARI risk may partly be based on several dynamic modifiable health risk factors. Smoking history based on the packs/day smoked was suggestive of increased ARI risk and again for time since smoking cessation prior to entering BCT. Additionally, physical fitness as assessed by a recruit's initial 1 mile run

time was also suggestive of increased risk of ARI among slower running recruits and for females it appears more strongly associated in some ARI models. Health promotion strategies of earlier smoking cessation and increased aerobic physical conditioning prior to entry of BCT may be suggested as a method to minimize ARI risk during BCT.

Future Research

Further studies are necessary to investigate the immunological parameters associated with smoking dose, time since smoking cessation, and run group (gender stratified) in high stressful environments that may further support these risk factors are attributable to increased ARI risk. Isolating specific ARI pathogens from subjects may also be beneficial to understanding if the selected risk factors differ by pathogen.

APPENDICES

LONG SURVEY

Acute Respiratory Infection Study Soldiers in Training Questionnaire

Thank you once again for agreeing to participate in our study of acute respiratory disease in Army Basic Combat Trainees. Before you get started, we have a few hints to help you complete the questionnaire.

- Please be sure to use a black ink pen for all questions.
- Fill in circles completely.
- Mistakes must be crossed out with an "X"

Shade Circles Like This--> ●

Not Like This--> ✗

- For accuracy, please print carefully and avoid touching the edges of the box as in the following two examples.

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

1	2	3	4	5	6	7	8	9	0
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- For dates or Social Security Number, please be sure and write out the full number and fill in all the circles.

- Whenever there is more than one box shown for a number, please be sure to fill in all boxes. Therefore "2" would be filled in as "02" or "002".

	0	3	/	2	3	/	1	9	7	2
0	●	○		○	○		○	○	○	○
1	○	○		○	○		●	○	○	○
2	○	○		●	○		○	○	○	●
3	○	●		○	●		○	○	○	○
4	○	○		○	○		○	○	○	○
5	○	○		○	○		○	○	○	○
6	○	○		○	○		○	○	○	○
7	○	○		○	○		○	○	●	○
8	○	○		○	○		○	○	○	○
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Thanks again for your participation.

[illegible][illegible]

☐ Female ☐ Male

Social Security Number

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Date of Birth (Month/Day/Year)

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2	○	○	○	○
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4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
0	○	○	○	○

Please enter the correct letter or number for your current military Basic Training unit.

Platoon	Bay	Company	Battalion	Sleeping Bay Type	Soldiers in Bay
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/>	<input type="radio"/> 60-person <input type="radio"/> 8-person <input type="radio"/> 4-person <input type="radio"/> 2-person	<input type="radio"/> 60 <input type="radio"/> 50 <input type="radio"/> 40 <input type="radio"/> 10 <input type="radio"/> 8 <input type="radio"/> 6 <input type="radio"/> 4 <input type="radio"/> 2 <input type="radio"/> 1
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2 <input type="radio"/>	2 <input type="radio"/>	B <input type="radio"/>	2 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
3 <input type="radio"/>	3 <input type="radio"/>	C <input type="radio"/>	3 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
4 <input type="radio"/>	4 <input type="radio"/>	D <input type="radio"/>	4 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
5 <input type="radio"/>	5 <input type="radio"/>	E <input type="radio"/>	5 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
		F <input type="radio"/>	6 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
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			8 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
			9 <input type="radio"/> <input type="radio"/> <input type="radio"/>		
			0 <input type="radio"/> <input type="radio"/> <input type="radio"/>		

Today's date (Month/Day/Year)

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7	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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0	<input checked="" type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

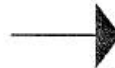
Week of Training

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Date arrived on Fort Jackson

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Days at 120th Reception Battalion

☐ 2
 ☐ 3
 ☐ 4
 ☐ 5
 ☐ More than 5 days

1. Have you had any of the following symptoms in the past two weeks (mark all that apply)?

- ☐ None (Skip to Question 5)
- ☐ Fever
- ☐ Fever greater than 100.5 degrees
- ☐ Sore throat
- ☐ Cough
- ☐ Runny nose
- ☐ Shortness of breath
- ☐ Headache
- ☐ Generalized muscle aches

2. How long did these symptoms last?

- ☐ 1-3 days
- ☐ 4-6 days
- ☐ 7-9 days
- ☐ 10 or more days

3. How would you describe your "cold"?

- ☐ Mild symptoms that didn't interfere with my training
- ☐ Moderate symptoms but I was still able to continue training
- ☐ Severe symptoms that stopped me from some training

4. What medical care did you seek for these symptoms?

- ☐ I did not seek medical care at all
- ☐ Went on sick call and saw a medic at my battalion aid station
- ☐ Went to the hospital but returned to my unit the same day
- ☐ Went to hospital and stayed over night

5. What best describes your racial/ethnic background (mark all that apply)?

- ☐ Native American or Alaska Native
- ☐ Pacific Islander/Filipino
- ☐ Black (African-American)
- ☐ Hispanic, Latino, or Spanish descent
- ☐ White (Caucasian)
- ☐ Other

6. What is the furthest you have gone in school?

- ☐ Some high school but no diploma
- ☐ GED (General Education Diploma)
- ☐ Graduated from high school
- ☐ Some college or technical school
- ☐ Graduated from trade or technical school
- ☐ Graduated from 4-year college or university
- ☐ Completed Masters or higher post-graduate degree

7. In the year prior to attending Army Basic Combat Training, where did you live most of the time?

- ☐ On a farm, ranch or in the country
- ☐ In a small town with less than 10,000 people
- ☐ In a small city with about 10,000 to 100,000 people
- ☐ In a large city or suburb with over 100,000 people
- ☐ Moved around a lot to different cities
- ☐ Not sure

8. Two letter abbreviation for Home state as used when mailing a letter.

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9. Give your best estimate of days of work/school you missed due to having a "cold" or "flu" during the year before attending Basic Training?

- ☐ None
- ☐ 1-3 days
- ☐ 4-6 days
- ☐ 7-9 days
- ☐ 10 or more days

10. In the year prior to attending Basic Training, how many small children age 5 or younger lived in your house?

- ☐ None
- ☐ One
- ☐ Two
- ☐ Three
- ☐ 4 or more

11. In the year prior to attending Basic Training, how many people (on average) lived with you in one house?

- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four
- ☐ Five
- ☐ Six or more

12. Have you smoked more than 100 cigarettes (5 packs) in your entire life?

- ☐ No (Skip to Question 15)
- ☐ Yes

13. Which best describes your smoking pattern?

- ☐ Some days but stopped more than a year before basic training
- ☐ Daily but stopped more than a year before attending basic training
- ☐ Some days but stopped more than a month before basic training
- ☐ Daily but stopped more than a month before basic training
- ☐ Some days, stopped within a month of basic training
- ☐ Daily, stopped within a month of basic training

14. When you smoked regularly, how many packs did you smoke a day?

- ☐ I have never smoked regularly
- ☐ About 1/2 pack or less per day
- ☐ About 1 pack a day
- ☐ Between 1 and 2 packs a day
- ☐ 2 packs or more

15. What has happened to your weight in the last year?

- ☐ Dieted and lost more than 10 pounds
- ☐ Lost more than 10 pounds without dieting
- ☐ Gained more than 10 pounds
- ☐ Neither gained nor lost more than 10 pounds

16. How difficult do you feel Basic Training will be for you PHYSICALLY?

- ☐ Not difficult at all
- ☐ Slightly difficult
- ☐ Difficult
- ☐ Very difficult
- ☐ The hardest thing I will have done in my life so far

17. How difficult do you feel Basic Training will be for you EMOTIONALLY?

- ☐ Not difficult at all
- ☐ Slightly difficult
- ☐ Difficult
- ☐ Very difficult
- ☐ The hardest thing I will have done in my life so far

18. Please enter your barracks bunk location.

Bunk location (choose only one)

- ☐ Near door (1/3 of room nearest to entrance)
- ☐ Middle (middle 1/3 of room)
- ☐ Far end (1/3 of room furthest from entrance)

19. Mark whether upper or lower bunk (choose only one).

- ☐ Upper bunk with head near wall
- ☐ Upper bunk with head near common walking area
- ☐ Lower bunk with head near wall
- ☐ Lower bunk with head near common walking area

Staff use only

Neighbor ARI

- ☐ No
- ☐ Yes, only one
- ☐ Yes, more than one

Disposition

- ☐ Return to duty
- ☐ Medical quarters
- ☐ Hospital admission

Provider ICD-9 Code

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Hospital visits during BCT

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Acute Respiratory Infection Study Soldiers in Training Short Questionnaire

Thank you once again for agreeing to participate in our study of acute respiratory disease in Army Basic Combat Trainees.

- This is an abbreviated questionnaire and should not be the first questionnaire you have completed. This questionnaire is record changes in your health status since you last completed a survey.

First Name

[illegible]

Last Name

[illegible]

Social Security Number

			-			-				
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Please enter the correct letter or number for your current military Basic Training unit.

Platoon

4

Bay

□

Company

□

Battalion

Sleeping Bay Type

- ☐ 60-person
- ☐ 8-person
- ☐ 4-person
- ☐ 3-person
- ☐ 2-person

Sleeping in room

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Room Number (1-61, 2-39 only)

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Bunk location (choose only one)

- Near door (1/3 of room nearest to entrance)
- Middle (middle 1/3 of room)
- Far end (1/3 of room furthest from entrance)

Upper or lower bunk (choose only one).

- ☐ Upper bunk with head near wall
- ☐ Upper bunk with head near common walking area
- ☐ Lower bunk with head near wall
- ☐ Lower bunk with head near common walking area

Today's date (Month/Day/Year)

	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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2	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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9	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
0	<input checked="" type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Week of Training

	<input type="text"/>
0	<input type="radio"/>
1	<input type="radio"/>
2	<input type="radio"/>
3	<input type="radio"/>
4	<input type="radio"/>
5	<input type="radio"/>
6	<input type="radio"/>
7	<input type="radio"/>
8	<input type="radio"/>
9	<input type="radio"/>

1. Have you had any of the following symptoms in the past two weeks (mark all that apply)?

- ☐ None (Skip to Question 5)
- ☐ Fever
- ☐ Fever greater than 100.5 degrees
- ☐ Sore throat
- ☐ Cough
- ☐ Runny nose
- ☐ Shortness of breath
- ☐ Headache
- ☐ Generalized muscle aches

2. How long did these symptoms last?

- ☐ 1-3 days
- ☐ 4-6 days
- ☐ 7-9 days
- ☐ 10 or more days

3. How would you describe your "cold"?

- ☐ Mild symptoms that didn't interfere with my training
- ☐ Moderate symptoms but I was still able to continue training
- ☐ Severe symptoms that stopped me from some training

4. What medical care did you seek for these symptoms?

- ☐ I did not seek medical care at all
- ☐ Went on sick call and saw a medic at my battalion aid station
- ☐ Went to the hospital but returned to my unit the same day
- ☐ Went to hospital and stayed over night

5. Your status on the previous questionnaire

- ☐ Neighbor of a Medical Quarters Case
- ☐ Medical Quarters Admission Case
- ☐ Seen at TMC/UCC for respiratory infection

Staff use only

Height in inches

<input type="text"/>	<input type="text"/>
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Weight in pounds

<input type="text"/>	<input type="text"/>	<input type="text"/>
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Run ability group

<input type="text"/>

Neighbor ARI

- ☐ No
- ☐ Yes, only one
- ☐ Yes, more than one

Relationship to Case

<input type="text"/>	-	<input type="text"/>
----------------------	---	----------------------

Disposition

- ☐ Return to duty
- ☐ Medical quarters
- ☐ Hospital admission

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